

CLAIMS

1. A protein involved in restoration of a cytoplasmic male sterile individual to fertility which has 14 or more pentatricopeptide repeat (hereafter may be abbreviated to PPR) motifs, wherein a group of the motifs is divided into 3 or more blocks, each of the individual blocks has at least 2 or more PPR motifs, and the block in a carboxyl terminal (C terminal) side has 4 PPR motifs.

2. The protein of claim 1 wherein the number of PPR motifs is 14 to 16.

3. The protein of claim 1 or 2 wherein the PPR motif group is divided into 3 blocks and each block has 5, 7, and 4 PPR motifs in the order from an amino terminal (N terminal).

4. The protein of any of claim 1 to 3 wherein the fourth amino acid located in a second PPR motif from the amino terminal (N terminal) is an amino acid other than serine, threonine and cysteine.

5. The protein of claim 4 wherein the fourth amino acid located in a second PPR motif from the amino terminal (N terminal) is any one of asparagine, glutamine, aspartic acid, glutamic acid or histidine.

6. The protein of any of claims 1 to 5 which further has a signal peptide sequence to translocate to a mitochondria at the amino terminal or has a sequence of -LysAspGluLeu- at the carboxyl terminal.

7. A protein involved in restoration of the cytoplasmic male sterile individual to fertility, which causes gel shift of a transcription product after contacting to the transcription product of a cytoplasmic male sterile gene.

8. A protein involved in restoration of the cytoplasmic male sterile individual to fertility, which has an amino acid sequence of SEQ ID NO.26.

9. A protein involved in restoration of the cytoplasmic male sterile individual to fertility, which has an amino acid sequence

of SEQ ID NO.27.

10. A protein involved in restoration of the cytoplasmic male sterile individual to fertility, which has an amino acid sequence of SEQ ID NO.28.

11. A protein involved in restoration of the cytoplasmic male sterile individual to fertility, which has an amino acid sequence of SEQ ID NO.29.

12. A protein of any of the followings:

(1) a protein having a sequence from 80th to 687th amino acids of an amino acid sequence of SEQ ID NO.3, the sequence from 80th to 687th amino acids of an amino acid sequence of SEQ ID NO.17, or the sequence from 82nd to 690th amino acids of an amino acid sequence of SEQ ID NO.19; or

(2) a protein which has an amino acid sequence wherein 1 or a plurality of amino acids are deleted, added, and/or substituted, in the sequence from 80th to 687th amino acids of an amino acid sequence of SEQ ID NO.3, the sequence from 80th to 687th amino acids of the amino acid sequence of SEQ ID NO.17, or the sequence from 82nd to 690th amino acids of an amino acid sequence of SEQ ID NO.19, and is involved in restoration of the cytoplasmic male sterile individual to fertility.

13. A protein of any of the followings:

(1) a protein having an amino acid sequence of SEQ ID NO.3, SEQ ID. 17, or SEQ ID NO.19; or

(2) a protein which has an amino acid sequence wherein 1 or a plurality of amino acids are deleted, added, and/or substituted, in the amino acid sequence of SEQ ID NO.3, SEQ ID NO.17, or SEQ ID NO.19, and is involved in restoration of the cytoplasmic male sterile individual to fertility.

14. The protein of any of claims 1 to 9 wherein the cytoplasmic male sterile individual has a cytoplasmic male sterile gene of Kosenia radish and/or Ogura radish or a homologue thereof.

15. A DNA encoding the protein of any of claims 1 to 10.

16. A DNA having a nucleotide sequence of SEQ ID NO.22.

17. A DNA having a nucleotide sequence of SEQ ID NO.23.

18. A DNA having a nucleotide sequence of SEQ ID NO.24.
19. A DNA having a nucleotide sequence of SEQ ID NO.25.
20. A DNA of any of the followings:
 - (1) a DNA having a nucleotide sequence of SEQ ID NO.2, SEQ ID NO.16, or SEQ ID NO.18; or
 - (2) a DNA which has a nucleotide sequence wherein 1 or a plurality of nucleotides are deleted, added, and/or substituted, in the nucleotide sequence of SEQ ID NO.2, SEQ ID NO.16, or SEQ ID NO.18, and is involved in restoration of the cytoplasmic male sterile individual to fertility; or
 - (3) a DNA which hybridizes with a DNA having a nucleotide sequence of SEQ ID NO.2, SEQ ID NO.16, and SEQ ID NO.18 under a stringent condition and is involved in restoration of the cytoplasmic male sterile individual to fertility.
21. A DNA of any of the followings:
 - (1) a DNA having a sequence from 3754th to 8553th nucleotides of the nucleotide sequence of SEQ ID NO.1 or a sequence from 812th to 3002th nucleotides of the nucleotide sequence of SEQ ID NO.15; or
 - (2) a DNA which has a nucleotide sequence wherein 1 or a plurality of nucleotide are deleted, added, and/or substituted, in the sequence from 3754th to 8553th nucleotides of the nucleotide sequence of SEQ ID NO.1, or a sequence from 812th to 3002th nucleotides of the nucleotide sequence of SEQ ID NO.15, and is involved in restoration of the cytoplasmic male sterile individual to fertility; or
 - (3) a DNA which hybridizes with a DNA having a sequence from 3754th to 8553th nucleotides of the nucleotide sequence of SEQ ID NO.1 or a sequence from 812th to 3002the nucleotides of the nucleotide sequence of SEQ ID NO.15 under a stringent condition, and is involved in restoration of the cytoplasmic male sterile individual to fertility.
22. A DNA of any of the followings:
 - (1) a DNA having a nucleotide sequences of SEQ ID NO.1 or 15;
or

(2) a DNA which has a nucleotide sequence wherein 1 or a plurality of nucleotides are deleted, added, and/or substituted in the nucleotide sequence of SEQ ID NO.1 or SEQ ID NO.15, and is involved in restoration of the cytoplasmic male sterile individual to fertility; or

(3) a DNA which hybridizes with a DNA having a nucleotide sequence of SEQ ID NO.1 or SEQ ID NO.15 under a stringent condition, and is involved in restoration of the cytoplasmic male sterile individual to fertility.

23. The DNA of any of claims 15 to 22 wherein the cytoplasmic male sterile individual has a cytoplasmic male sterile gene of Kosena radish and/or Ogura radish or a homologue thereof.

24. A vector containing DNA of any of claims 15 to 23.

25. A transformant having the DNA of any of claims 15 to 23 or the vector of claim 24.

26. The transformant of claim 25 which is a transformed plant.

27. A method for the restoration of the cytoplasmic male sterile individual to fertility wherein DNA of any of claims 15 to 23 is used.

28. A transformant having a cytoplasmic male sterile gene wherein a partial or full length of DNA of any of claims 15 to 23 is introduced with an induction type promoter to a cell having DNA of any of claims 15 to 23, so that the transformant can regulate an expression of the cytoplasmic male sterile gene.

29. A method for maintaining the cytoplasmic male sterile line by using the transformant of claim 28.

30. A method for detecting a gene involved in restoration from the cytoplasmic male sterile, wherein 15 to 50mer oligonucleotide primer freely designed from the DNA of any of claims 15 to 23 or probe of at least 15 mer consisting of all or a part of the DNA of any of claims 15 to 23 is used, and the quantity of the nucleotide sequence amplified by the primer or the quantity of the nucleotide sequence detected by the probe in an organism sample of interest is confirmed to be 1 gene or more in a genome.

31. A promoter DNA having a sequence from 3754th to 5091th nucleotides of a nucleotide sequence of SEQ ID NO.1 or a sequence from 1st to 811th nucleotides of a nucleotide sequence of SEQ ID NO.15.

32. A plant-transforming vector which comprises a promoter DNA having an ability of transcribing an mRNA at least in an anther and the DNA of any of claims 15 to 23.

33. The plant-transforming vector of claim 32, wherein the promoter DNA having an ability of transcribing an mRNA in an anther is a promoter DNA having 3754th to 5091st nucleotide sequence of the nucleotide sequence of SEQ ID NO.1 or 1st to 811st nucleotide sequence of the nucleotide sequence of SEQ ID NO.15.

34. A transformed plant having the vector of claim 32 or 33.

35. The transformant of claim 25, 26 or 27, or the transformed plant of claim 34, which has DNA encoding a protein involving in restoration of a cytoplasmic male sterile plant to fertility as a homozygote.

36. A transformant of claim 25, 26, 27 or 35 or a transformed plant of claim 34 or 35 wherein, when the transformant or the transformed plant is regenerated, the regenerated individual can restore the cytoplasmic male sterility to fertile.

37. A seed, pollen, protoplast, cell, vegetative portion, hypocotyl, gamete or root, which is obtained from the transformant of claim 25, 26, 27, 35 or 36 or the transformed plant of claim 34, 35 or 36.

38. A transformant of a Brassica plant, wherein a glucosinolate content in the seed which is obtained from the transformant of claim 25, 26, 27, 35 or 36 being a transformant of the Brassica plant or from the transformed plant of claim 34, 35 or 36 satisfies the Canola standard.

39. A seed which is obtained from the transformant of the Brassica plant of claim 38.

40. A method for producing a hybrid plant seed having fertility restoration ability, wherein a cytoplasmic male sterile line

plant is used as a mother, the transformed plant of claim 35, 36 or 38 as a fertility restoring line plant is used as a pollen parent, and both of them are crossed.

41. The method for producing a hybrid plant seed according to claim 40, wherein the cytoplasmic male sterile line plant is a cytoplasmic male sterile hybrid line derived from Ogura or Kosenia radish.

42. A hybrid plant seed which is produced by the method of claim 40 or 41.

43. The hybrid plant seed of claim 42, wherein the plant belongs to the genus Brassica.

44. The seed of the plant belonging to the genus Brassica according to claim 42 or 43, wherein a glucosinolate content in the seed satisfies the Canola standard.

45. A method for producing seed oil, wherein the plant seed of any of claims 42 to 44 is inseminated, a seed is collected from the grown plant, and an oil is collected from the collected seed.

46. A seed oil which is produced by the method of claim 45.

47. A seed, pollen, protoplast, cell, vegetative portion, hypocotyl, gamete or a root, which is obtained by planting and growing the hybrid plant seed of claim 42 or 43.